worked by one central clock movement, each or all being readily thrown out of gear at will. The marking is effected by steel prickers driven by electro-magnets, on the same principle as in the chronograph of the Royal Observatory, Greenwich, though the mechanical details were different. These prickers can also be thrown out of action by a convenient arrangement of resistance coils. The length of a single second of time can, by changing two wheels, be made either one, three-quarters, or half an inch. I had prescribed that the central clock work should be regulated either by the late Léon Foucault's lever governor or by Mr. Siemens' centrifugal fluid governor, but the maker, without consulting me, applied a Watts ball governor with friction-brake, such as is employed for the driving-clock of equatoreals. I did not expect that this comparatively primitive contrivance would secure a sufficiently uniform velocity. But on trial by Capt. Campbell, R.E., and myself, it was found to answer its purpose so well that I am inclined to think a great deal of needless refinement and expense has been wasted on elaborate governors for chronographs.

Standard Clock.—This is by Messrs. Cooke, of York, and has nothing peculiar in its construction. It has a Graham's dead beat escapement, and a mercurial (metal jar) compensated pendulum, with the contact apparatus necessary for connecting it electrically with the chronograph.

Three Journeyman Clocks.—These were intended by me to be connected electrically with the Standard Clock, and thus show identical time for each of the principal instruments from which the latter might not be visible. I was not satisfied with the mode of driving adopted by the makers, and should have had them altered if time had admitted. Col. Tennant is also dissatisfied with them, but I hope that, with careful adjustment and attention to the batteries and contacts, they may be found effective during the short period of the phenomenon.

It fortunately happened that whilst these instruments were undergoing examination by me, Capt. W. A. Campbell, R.E., of the G. T. Survey of India, who is to assist Col. Tennant with the Venus observations, was in England. The Government, on my application, appointed Capt. Campbell to assist me in testing the instruments, and thus the two objects were gained of securing his valuable experience and skill, and of familiarising him with the instruments which he would have to use.

I have heard from Col. Tennant of the safe arrival at Roorkee of the photoheliograph, altazimuth, chromograph, and clocks, and of the expected arrival in a few days of the Equatoreal, his last letter to me to that effect being dated 9th Oct., 1874. There would only remain the Transit Instrument, which was much delayed in construction. It was despatched hence on Sept. 18, 1874, and is no doubt now in Col. Tennant's hands.

In the foregoing statement I have confined myself to those arrangements which I have been personally concerned in making. But other places in India will be provided with equipments more or less complete for observing the Transit of Venus—amongst others I may mention Peshawur, Bombay, and probably more than one station in the southern part of the peninsula under the care of Mr. Pogson, Government Astronomer at Madras. The Government of India has thus not been unmindful of the just claims of astronomical science.

A. Strange, Lieut.-Colonel,
Inspector of Scientific Instruments
to the Government of India

Lambeth Observatory, Nov. 1874

PRACTICAL SCIENCE AT CAMBRIDGE

DR. MICHAEL FOSTER, in concluding his course of Practical Physiology this term, remarked on the diligence and industry of his class under many difficulties. At the beginning of the term he asked their indulgence for the imperfect accommodation he was able to offer them. Thirty students had been entered, and the space available was about sufficient, properly, for ten. Three students had to be placed at each table, instead of one. Several other gentlemen joined the class subsequently, making the class number about thirty-five. Two ladies also attended the lectures, and were provided with a separate place of study. Dr. Foster at his last lecture said that in the previous year the want of accommodation had been so keenly felt by himself and class that he was inclined to discontinue his course. He had, however, conducted it through another term, with a larger number of students; and, as the result, although he expressed pleasure at the work accomplished by his class, he was more than ever inclined to give it up. The present course would, however, be completed next term; but he was not able to promise its repetition in the succeeding winter. Want of accommodation militated so greatly against the quality of the work done, and so limited the kind of work that could be attempted, that the benefit seemed almost to be outweighed by the limitations and disheartening accessories.

The publication of these remarks may serve to draw attention to the general condition of practical science in Cambridge. Chemistry and geology are perhaps the subjects for the practical study of which we now have the most reasonable facilities. The Chemical Laboratory has been recently enlarged and improved, and in addition to the ordinary practical courses Prof. Liveing has this term given lectures with practical illustrations in spectroscopic analysis. The lectures have been given during four successive hours of the afternoon, to four sets of students, the number of students in each class being limited to four or five; so that thoroughly efficient work could be done. The facilities for study at the Geological Museum have been improved by Prof. Hughes. A typical collection of fossils has been selected and arranged by Mr. Keeping, and provided with catalogues. A typical series of minerals has been arranged and catalogued by Mr. W. E. Koch, B.A., of St. John's College, derived from the ample stores accumulated by the late Prof. Sedgwick. Several large series of rock specimens have been more conveniently arranged for inspection, including those catalogued by the Rev. T. G. Bonney. In addition, advanced students have free access to the many valuable special collections in the Woodwardian Museum. The Geological Library in the museum has been improved and catalogued; a valuable section-cutter and an excellent microscope have been purchased, and in other ways the means for the practical study of geology, so far as it can be carried on in a museum, have been greatly improved.

In Experimental Physics the best conditions for practical study have been secured in the building of the Cavendish Laboratory, in its being furnished with some of the most perfect and valuable physical apparatus in existence, and in the appointment of Prof. Clerk Maxwell and his able demonstrator, Mr. Garnett. No doubt at the earliest possible moment a practical elementary course will be organised, to include those observations which every student of natural science should become familiar with. Sufficient time has not yet elapsed since the completion of the laboratory for the establishment of such an elementary class; but when it is established a great boon will be conferred on Natural Science students, who, in the study of biology and geology, labour under many difficulties caused by a want of sufficient practical acquaintance with physics. It would be very desirable, also, if some elementary non-mathematical lectures on physics could be given for the benefit of Natural Science students; such lectures might be given by the Demonstrator, so as not to interfere unduly with Prof. Maxwell's researches and advanced mathematical lectures. It is true that Mr. Trotter gives valuable lectures on physics

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at Trinity College, but these are restricted to members of those colleges which are associated with Trinity for Natural Science studies.

The great hindrance to the success of the Cavendish Laboratory at present is the system fostered by the Mathematical Tripos. The men who would most naturally be the practical workers in the laboratory are compelled to refrain from practical work if they would gain the best possible place in the Tripos list. Very few have courage so far to peril their place or to resign their hopes as to spend any valuable portion of their time on practical work; for, while they might be acquiring sound physical conceptions and going through long laborious details, others are assiduously cramming book-work, wearing out their energy in attacking those problems which are here set before the student as affording the best mental training, and in learning those short cuts and dodges which conduce to obtaining marks in an examination. For a man to do practical work in physics at Cambridge implies considerable exercise of courage and self-sacrifice.

Students of the foregoing subjects, however, have better facilities for study than students of Biology. In Practical Physiology and Histology almost everything is required. A large room, properly lighted and fitted, is needed for elementary courses; and, considering the numbers already attracted to Dr. Foster's summer and winter classes, in spite of difficulties and defects, it would seem desirable to provide accommodation for at least a hundred students. Rooms should also be provided, specially adapted for advanced work in Histology, for researches in Physiology, for preparation of experiments and of materials for the classes, and, in addition, a good lecture-room.

In Comparative Anatomy and Zoology the museum has been much improved in the last few years, but its growth is greatly restricted by want of funds. The accommodation for practical dissection of animals consists only of the superintendent's private room, which, at the cost of great inconvenience, has been generously thrown open to students.

Finally, as regards Botany, while there are a good garden and a carefully kept herbarium for systematic study, there is no class of any kind for practical study of Vegetable Histology and Physiology. And yet, recently, the standard for obtaining an ordinary degree in Botany has been considerably raised, and students are expected to show knowledge of the forms, sizes, and development of cells of every kind. The demand for an acquaintance with Vegetable Histology, which, to be real, must be acquired by assiduous and carefully directed microscopical study, while no instruction in such work is given, puts a premium on cramming of the most unfruitful kind, and reduces natural science studies to a lower level than those mathematical and classical studies whose exclusive pursuit scientific men desire to see abandoned. It would be better to examine only in those portions of morphology and classification which can be learnt in a botanic garden, than to set elaborate questions in Histology and Physiology which necessitate elaborate cramming on the part of the student.

G. T. BETTANY

Cambridge, Dec. 10

M. BECQUEREL ON SOLAR PHYSICS

THE Paris Academy of Sciences having appointed a Commission to consider the founding of an Observatory for Physical Astronomy in the vicinity of Paris, M. Becquerel the elder, a member of the Commission, has expressed his opinion on the subject in a report of which the following is a translation:—

To study the physical constitution of the sun and stars, Astronomy employs in general telescopes and the spectroscope; this last instrument shows us that the heavenly bodies are composed of the same elements that are found in the earth; whence it may be concluded that the forces governing matter are of universal existence. This question I have considered in a work now going through the press, and which will appear before the end of the year; its title is "On the Physico-chemical Forces and their Intervention in the Production of the Phenomena of Organic and Inorganic Nature." All questions relating to these subjects are there treated, not theoretically, but by the experimental method.

I have endeavoured to show that to arrive at a knowledge of the sun's constitution it is necessary to call to our aid the geological constitution of the globe and volcanic phenomena from the earliest times down to the present epoch.

The following are the reasons which have led me thus to deal with the subject:—

The identity of formation of the sun and earth and of all the planets which gravitate around our principal star being admitted, the conclusion may be drawn that his present physical condition is the same as that of our planet during the first periods of its formation, when the crust did not exist or had but little thickness. The cooling of the earth has been considerably more rapid than that of the sun by the effects of celestial radiation, the volume of the sun being 1,326,480 times that of the earth. It is thus permitted to compare the chemical and physical effects occurring in the sun at present with those which were produced in the earth at its origin, from which conclusions may be drawn as to the actual constitution of this star.

The collection of vapours which constituted the earth, submitted to a gradual cooling, passed successively from the gaseous to the liquid state, after which its surface became covered by a solid crust, of which the thickness increased with time. There were then produced a mass of chemical and physical phenomena.

We may distinguish three principal calorific epochs during the formation of our planet.

The first is that in which all the elements were in a gaseous state in consequence of a temperature excessively elevated; all the constituents were then dissociated.

The second is that in which, the temperature being sufficiently lowered, affinities commenced to exercise their action; the compounds formed passed successively from the gaseous to the liquid and solid states. During all the chemical reactions which occurred there would be produced an enormous disengagement of electricity arising from the energy of these reactions, and, as a consequence, a recomposition of the two electricities which would rend with vivid gleams the atmosphere already formed. Thunder would burst forth from all parts.

The third epoch is that in which the temperature, being sufficiently lowered and below 100°, the quantity of water formed would increase so much the more as the temperature was less elevated. This primordial water contained, probably, carbonic, sulphuric, and other acids which would saturate bases; it is to the reactions produced that must be attributed the formation of the great masses of limestone found in various parts of the earth's crust.

I have been led also in my work to treat of the calorific state of the earth in the first phases of its formation, as also of the volcanic phenomena of the same epochs.

As a consequence of the subjects discussed, I have been led to show that atmospheric electricity had a solar origin, and is the cause of the aurora and probably of the luminous phenomena which are produced beyond our atmosphere. I here limit myself to the indication of the consequences to which the study of the forces of nature has led me.

From what precedes it will be seen that the study of the constitution of the sun requires the conjunction, not only of astronomy, but of observers having general knowledge in Physics, Geology, and Chemistry, and possessing a thoroughly practical knowledge of the spectroscope.

R. M.

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